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Comparative Analysis of Imaging Modalities in the Preoperative Assessment of Nodal Metastasis in Esophageal Cancer

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Preoperative radiological findings of nodal status in 74 patients, using endoscopic ultrasonography (EUS), computed tomography (CT), ultrasonography (US), and magnetic resonance imaging (MRI), were compared to histopathology reports following transthoracic total esophagectomy with radical lymphadenectomy (TTE), involving complete dissection of the mediastinal and abdominal nodes and lower cervical lymph nodes. Accuracy, sensitivity, and specificity of each radiological investigation were calculated for each anatomic group of nodes. Statistical analysis revealed that EUS is more accurate and significantly more sensitive ($P < 0.01$) for lymph nodes along the right recurrent laryngeal nerve and those in the upper and mid-periesophageal, infracarinal locations. Paratracheal and lower paraesophageal nodes are assessed better using CT whereas MRI is better for mid-paraesophageal and infra-aortic nodes. US is most accurate and sensitive for evaluation of cervical and abdominal nodes ($P < 0.01$).

KEY WORDS: **endoscopic ultrasonography, computed tomography, magnetic resonance imaging, mediastinal nodes, preoperative staging**

INTRODUCTION

The ability to stage an esophageal cancer accurately prior to therapy has assumed increasing importance, largely due to the diversity in surgical approaches available. Early tumors without lymph node metastasis may be effectively treated with a conservative approach, whereas a radical curative resection may be necessary in those with definite lymph node metastasis. The preoperative criteria for selection depends entirely on clinical and radiological imaging modalities. Various imaging techniques, including endoscopic ultrasonography (EUS), computed tomography (CT), ultrasonography (US), and magnetic resonance imaging (MRI), have been effective in the staging of esophageal cancer. Many reports have determined the efficacy of individual radiological investigative modalities [1–4].

Our study is unique insofar as it satisfies the following criteria: (1) it incorporates the evaluation of all four radiological investigations (EUS, CT, MRI, and US) performed in the same individual patient; (2) it compares each radiological investigation in each individual anatomic site; and (3) radical lymphadenectomy being a complete dissection of all lymph nodes in the area allows accurate histologic confirmation in each anatomic region. This study would subsequently form the basis for the recommendation of a standard radiological investigation profile for patients with esophageal cancer.

MATERIALS AND METHODS

Seventy-four patients treated at the Kurume University Hospital during 1985–1991 were studied. All patients underwent EUS, CT, and routine US of the abdomen and neck preoperatively. MRI was used in only 44 patients,

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as this investigation was available only after 1989. Patients with an impassable esophageal disease who could not undergo a complete endoscopy were excluded, as EUS evaluation would not be possible. The radiological criteria for assessment of the nodal status for each investigative modality are enumerated.

EUS: If a node was found to be round or elliptical in shape, >0.5 cm in smallest diameter, with a discrete margin and a hypoechoic heterogeneous echostructure, it was termed metastatic.

CT: a node >1 cm in size, irrespective of density, was termed metastatic, and nodes <0.5 cm on CT were termed negative for metastasis. Nodes of 0.5–1 cm were termed metastatic only if the density was high following intravenous contrast enhancement.

MRI: A node >1 cm in size was termed metastatic irrespective of its density, whereas nodes of <0.5 cm were reported as negative. Subsequently, within 2 weeks of this procedure, all patients underwent a total transthoracic esophagectomy with a radical lymphadenectomy (TTE) involving the complete dissection of the lymph nodes in the lower neck, mediastinum, and abdomen. Specimens were reviewed independently by the pathologist, and the histopathologic findings were compared with those of the radiologist for each individual group of nodes. Accuracy, sensitivity, and specificity were calculated for each given anatomic group of nodes, and the results were analyzed.

A statistical analysis using the chi-square method enabled us to determine those anatomic lymph node groups most effectively assessed by a particular investigative modality.

RESULTS

Accuracy, sensitivity, and specificity for CT and MRI are summarized in Table I and for EUS and US in Table II.

Mediastinal Nodes

CT was accurate for lower paraesophageal and posterior mediastinal nodes, but the results were not statistically significant ($P > 0.05$). EUS was found to be most accurate for the recurrent laryngeal nerve node, upper paraesophageal and infra-aortic group. Of these, the infra-aortic group alone showed a statistically significant result. MRI was accurate in detection of mid-periesophageal group, although the difference from the other investigations was not statistically significant. EUS was significantly more sensitive for the right recurrent laryngeal nerve ($P < 0.01$), upper periesophageal ($P < 0.01$), infracarinal ($P < 0.01$), and lower paraesophageal nodes ($P > 0.05$). CT was more sensitive for the left paratracheal ($P < 0.01$) and the lower paraesophageal nodes ($P < 0.01$). The sensitivity of MRI was statistically significant ($P < 0.05$) for infra-aortic and mid-paraesophageal nodes. EUS was most specific for right recurrent laryngeal nerve, left paratracheal, upper paraesophageal and lower posterior mediastinal nodes. CT was specific only for infracarinal nodes and right recurrent laryngeal nerve node, whereas MRI was specific for infra-aortic and mid and lower paraesophageal nodes. The US showed a greater accuracy for the cervical paraesophageal nodes, lesser curvature and the left gastric nodes. The MRI was most accurate for supraclavicular and the paracardiac nodes although this difference was not statistically significant. The US showed a high degree of sensitivity as compared to the other modalities for cervical paraesophageal ($P < 0.01$) and lesser curvature nodes ($P > 0.05$). CT was sensitive for supraclavicular and the cervical paraesophageal nodes. Paracardiac nodes were poorly assessed by all investigative modalities. These results suggest that US is as effective as a CT in the cervical and abdominal region. US was the most specific investigation for most groups of nodes, namely the cervical paraesophageal, paracardiac, lesser curvature, and the left gastric nodes.

DISCUSSION

EUS has an advantage over the other imaging modalities, since it can assess the size, shape, margin, and internal echogenicity of the nodes. Tio et al. [5], Murata et al. [6], and Aibe et al. [7] have defined the criteria of metastatic nodes as being enlarged, poorly echogenic, heterogeneous with distinct margins. Furthermore, the overall accuracy of 87.84% in our study is comparable to the reports in literature [8,9]. EUS is significantly more accurate for periesophageal nodes than CT or MRI. The accuracy varies inversely with the axial distance of the nodes from the esophageal wall. EUS was accurate in detecting infra-aortic and infracarinal nodes as well, which may be missed on CT and MRI, as they are slice images and it depends on whether the node is included in a particular section. Endosonography has shown a consistently superior sensitivity in diagnosing the metastatic nodes than CT even in other reports [10].

CT appears to be less accurate in detecting involvement of regional lymphadenopathy in esophageal cancer, especially those of the periesophageal region [11,12]. Various investigators have suggested different criteria for positivity. Picus et al. [11] used a lymph node diameter of 6 mm as the upper limit of normal, whereas Thompson et al. [12] regarded a size of ≥10 mm to be metastatic. Enlarged nodes adjacent to the tumor are difficult to distinguish from contiguous tumor spread [13,14]. The limitations of CT arise from the technical interpretation of images that may be influenced by vertical tangential scanning phenomenon and a horizontal masking. Metastatic nodes may be interpreted as uninvolved due to these phenomena, giving rise to false-negative results.

TABLE I. Percentage Efficacy of Computed Tomography and Magnetic Resonance Imaging in Preoperative Assessment of Nodal Metastasis in Esophageal Cancer

	CT			MRI		
Lymph node group	A	Se	Sp	A	Se	Sp
Right recurrent laryngeal nerve	72	21	92	77	31	96
Left paratracheal	94	63*	90	94	33	96
Upper paraesophageal	90	40	93	91	20	93
Infra-aortic	68	10	96	70	48	98*
Infracarinal	90	40	98*	90	50	97
Mid-paraesophageal	77	14	76	84*	58	88*
Lower posterior mediastinal	96*	10	60	92	18	72
Lower paraesophageal	92*	66*	93	91	20	96*
Cervical paraesophageal	92	75*	94	94	50	94
Supraclavicular	90	57	98	93	16	95
Paracardiac	79	33	76	82	33	82
Lesser curvature	80	8	76	82	10	72
Left gastric	88	33	88	89	33	70

*$P > 0.05$.
A, accuracy; Se, sensitivity; Sp, specificity.

TABLE II. Percentage Efficacy of Endoscopic Ultrasonography and Ultrasonography in Preoperative Assessment of Nodal Metastasis in Esophageal Cancer

	EUS			US		
Lymph node group	A	Se	Sp	A	Se	Sp
Right recurrent laryngeal nerve	80*	42*	96*			
Left paratracheal	94	25	97*	—	—	—
Upper paraesophageal	94*	40	97*	—	—	—
Infra-aortic	97*	33	96	—	—	—
Infracarinal	89	60	93	—	—	—
Mid-paraesophageal	70	28	68	—	—	—
Lower posterior mediastinal	95	20*	80*	—	—	—
Lower paraesophageal	86	20	87	—	—	—
Cervical paraesophageal	92	66	96	94*	75*	97*
Supraclavicular	92	28	98	92	55	98
Paracardiac	—	—	—	80	33	85
Lesser curvature	—	—	—	84*	14*	90*
Left gastric	—	—	—	92*	33	92*

*$P > 0.05$.
A, accuracy; Se, sensitivity; Sp, specificity.

Normal mediastinal nodes have a diameter of 3–6 mm and may occasionally be visualized on CT. However, it must be noted that in certain regions such as paratracheal and hilar areas normal nodes may occasionally be enlarged yet nonmetastatic, owing to the increased drainage in these areas. These may be misinterpreted and may be the reason for false-positive results. In our study, hilar nodes were effectively assessed by CT. Reports from the literature show that hilar nodes are easier to detect due to the clear axial boundaries formed by the azygos vein, tracheal bifurcation, aorta, superior vena cava, and the esophagus. Conversely, as confirmed in our findings, the infra-aortic node is difficult to assess as the aortopulmonary window is usually narrow in young patients, and a node in this area may be missed. Moreover, large lymph node conglomerates may be interpreted as being a metastatic mass. The overall accuracy of CT in mediastinal nodes has been reported as 72% and 61% by Lea et al. [15] and Quint et al. [16]. The overall accuracy of CT in abdominal nodes has been variable in the literature between 57% [17], 39% [18], 80% [11], and 87% [19]. These studies have not analyzed the anatomic variability of the accuracy values.

A review of the literature suggests that studies of MRI in esophageal cancer has received less attention. Reports analyzing the efficacy of MRI are few and show relatively equivocal results [20–22]. The primary difficulties are small numbers of patients, different tumor characteristics, and varied surgical procedures, making a comprehensive study difficult. Takashima et al. [23] report an overall

accuracy for MRI of 68% for abdominal nodes, whereas Petrillo et al. [21] report MRI accuracy of 84% for regional lymph nodes and 72% for abdominal nodes. Lehr et al. [20] found that the MRI was more sensitive than CT in detecting perigastric and celiac nodes, although a correlation with US, as revealed in our study, suggests that the latter is far superior in detection of abdominal node than any other investigation.

The efficacy of US in detection of supraclavicular and cervical paratracheal nodes was superior to all other investigative modalities. Moreover the sensitivity and the specificity for these groups of nodes was also high. In a study by van Overhagen et al. [24], the US was also effective in achieving a tissue diagnosis by a US-guided fine-needle aspiration biopsy of the supraclavicular nodes in esophageal cancer [24]. In the abdominal region too, US was far better than CT or MRI in terms of accuracy, sensitivity, and specificity. In addition, it is cheap and easily available and remains the investigation of choice in staging of the neck and abdominal nodes.

CONCLUSION

Based on these observations, we recommend that patients with esophageal carcinoma have the following radiologic investigation profile: (1) EUS and a CT of the thorax for assessment of mediastinal nodes, (2) US for the abdominal and cervical nodes, and (3) MRI reserved for those patients in whom the standard investigations cannot be performed due to stenosis or wherein their results need further confirmation.

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